MATERIALS BUREAU

TECHNICAL REPORT 94-2

CONSTRUCTION OF A FULL-DEPTH ASPHALT PAVEMENT USING RECYCLED TIRE RUBBER: THE ROUTE 32 PILOT PROJECT

MARCH 1994

M.A.P. CODE 7.42-6-94-2

A NEW NEW YORK

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

MARIO M. CUOMO, Governor

JOHN C. EGAN, Commissioner

TECHNICAL REPORT 94-2

CONSTRUCTION OF A FULL-DEPTH ASPHALT PAVEMENT
USING RECYCLED TIRE RUBBER: THE ROUTE 32 PILOT PROJECT

FINAL REPORT

Prepared by

Jill Martin

March, 1994

MATERIALS BUREAU
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NEW YORK STATE DEPARTMENT OF TRANSPORTATION
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M.A.P. CODE 7.42-6-94-2

ABSTRACT

This report describes the construction of a rubber-modified hot-mix asphalt pavement on Route 32 in Albany County, in NYSDOT's Region 1, using recycled-tire rubber. It includes plant operations and construction procedures for both crumb-rubber-modified and rubber-modified asphalt pavements.

ACRONYMS AND DEFINITIONS

AR: asphalt rubber (asphalt cement binder modified with CRM)

CRM: crumb-rubber modifier (crumb rubber derived from scrap-tire rubber with a gradation of less than 1/4 in.)

HMA: hot-mix asphalt

ISTEA: Intermodal Surface Transportation Efficiency Act of 1991

RUMAC: rubber-modified hot-mix asphalt (CRM blended with heated aggregate before adding asphalt cement)

RTR: recycled-tire rubber

AC: asphalt cement

FWD: falling-weight deflectometer (a device supplying data on structural strength of a pavement section)

CONTENTS

I. INTRODUCTION

A. Background

In 1994, the New York State Department of Transportation must begin paving with rubber-modified asphalt concrete to meet provisions of Section 1038 of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. This legislation requires each state to incorporate crumb rubber obtained from scrap tires into hot-mix asphalt (HMA) pavements. The 1994 quantity of crumb rubber to be used is calculated based on 1-percent usage in 5 percent of the total tonnage of HMA, financed either wholly or in part by federal funds. Due to the Department's limited experience in successfully incorporating scrap rubber into HMA, it was decided that a pilot project would be beneficial to study the effects of recycled-tire rubber (RTR) in HMA. Route 32 between Coeymans and Westerlo in Albany County in NYSDOT Region 1 was selected as a suitable candidate for this investigation. The Engineering Research and Development Bureau and Materials Bureau developed an experimental plan for the pilot project.

B. Objectives

In this reconstruction, the Department planned to gain experience and knowledge in use of crumb-rubber modifier (CRM) and asphalt rubber in HMA. The following issues were to be addressed:

1. Hot-Mix Plant

   What are the effects on plant operations and mix quality of adding asphalt rubber (AR) and CRM to HMA?

2. Construction

   What are the effects of AR and CRM on the paving and compaction processes?

3. Health Effects

   What are effects on plant personnel and the paving crew of fumes generated as a result of adding tire rubber to the mix and asphalt cement?

4. Performance

   How do CRM- and AR-modified pavements perform compared to conventional HMA pavements?

5. Cost

   Will the additional cost of adding CRM to HMA be offset by a longer service life?

C. Materials

The rubber was added to the HMA by the wet and dry process. The wet process consists of blending tire crumb rubber into the asphalt cement and allowing it to react before adding it into the mix, producing AR. For this project the AR, known as "Ecoflex," was supplied by Bitumar Inc. of Montreal, Quebec. The Ecoflex process uses RTR to produce a rubber composite asphalt containing 10-percent RTR. This material is terminal-blended and shipped to the plant ready to use. Among the manufacturer's claims are the following:

1. It provides substantial performance improvements, such as resistance to aging, rutting, and cracking, as well as improved binding qualities.

2. It does not produce toxic fumes and poses no threat to the environment and/or worker's health.

3. It allows for eventual recycling of the pavement itself.

4. It involves complete dissolution of the RTR to ensure homogeneity, which permits extended storage. Typically, rubber-modified asphalt cement has a relatively short storage life (a few hours) but Ecoflex can be stored for several months.

The dry process consists of adding RTR to the aggregate at the pugmill and then mixing with a standard asphalt cement, producing a RUMAC. In this project, 1- and 2-percent crumb rubber was added to the aggregate by weight of the total mix. When CRM is added to HMA, more asphalt cement is necessary because the rubber absorbs some of the asphalt. For mixes used on this project, asphalt cement content was increased 0.2 percent for each 1 percent of rubber added. The CRM for this process was supplied by Baker Rubber Inc. of South Bend, Indiana. The CRM gradation used is listed in Appendix A.

D. Project Description

Route 32, a two-lane highway approximately 28 ft wide, was scheduled for about 3 miles of reconstruction with full-depth, 9-in. thick asphalt pavement. An order-on-contract was processed to include construction of four test sections on this project, using specifications prepared by the Materials Bureau. A control section, using all conventional materials, was also built. Each test section was 2000 ft long. The 9-in. pavement section was built with two 3-in. layers of Type 1 base, 1.5 in. of Type 3 binder, and 1.5 in. of Type 6F top. The test sections were constructed with various combinations of conventional HMA, RUMAC, and AR HMA. The proposed test sections were to be constructed as listed in Table 1.

Table 1. Pavement sections as proposed and as built.

Section	Stationing	Course and Depth, in. Top (1.5")	Binder (1.4")	Base (3")	Base (3")
Control	282+30 to 302+30	Conventional	Conventional	Conventional	Conventional
Test 1	302+30 to 322+30	AR	Conventional	Conventional	Conventional
Test 2	322+30 to 342+30	AR	AR	AR	AR
Test 3	342+30 to 362+30				
Proposed		1% RUMAC	2% RUMAC	2% RUMAC	2% RUMAC
As-Built		Conventional	2% RUMAC	2% RUMAC	2% RUMAC
Test 4	362+30 to 382+30				
Proposed		Conventional	2% RUMAC	2% RUMAC	2% RUMAC
As-Built		Conventional	1% RUMAC	2% RUMAC	2% RUMAC

AR = Asphalt-Rubber, RUMAC = Rubber-Modified Hot-Mix Asphalt Concrete.

II. PLANT OPERATIONS AND CONSTRUCTION

A. Plant Operations

1. Asphalt Rubber (AR)

The Bitumar product (Ecoflex) was used for this project because of its availability and extended storage life. It is claimed that hot-mix plants can receive, handle, and store Ecoflex in the same manner as any conventional AC. However, a pump at the plant failed due to the increased viscosity of the AR which required extra power to pump the asphalt rubber.

2. Rubber-Modified Hot-Mix Asphalt (RUMAC)

The CRM supplied by Baker Rubber Inc. was packaged in 25-lb low-melt polyethylene bags and delivered on pallets. About 2200 lb of CRM were on each pallet, and a large storage area was needed for the CRM.

Production of the RUMAC was slow. The 3-ton batch plant produced less than 100 tons of RUMAC per hour. It regularly produces 150 tons per hour of conventional HMA. The reduced production was due in part to adding the CRM manually. The contractor used a forklift to raise pallets of 25-lb bags onto a platform near the pugmill, where they were added as needed. Depending on the amount of CRM being added to the mix, three to five people were required to supply and add CRM to the pugmill.

Because the CRM was added manually into the pugmill, it was necessary to bypass the plant automation. The plant operator repeatedly had to override the automation to open the gate to the pugmill, while workers manually dumped CRM in whole bags into it. Leaving the pugmill doors open generated considerable dust, requiring workers to wear protective clothing, goggles,

and masks. To ensure adequate mixing, the aggregate and CRM were combined and mixed for a minimum of 25 seconds before the AC was added.

During production of both the RUMAC and AR mixes, the temperature at the plant was increased about 25 deg F to increase mix workability. The average temperature of these mixes was approximately 300 deg F. The plant inspector and crew complained about the odor present during production of both the RUMAC and the AR mixes.

B. Construction

A control section was built with conventional mixes before placing the test sections. Control section performance will be compared to that of the RUMAC and AR sections. Mix designs for all test sections are included in Appendix A.

1. Asphalt Rubber (AR)

In July 1993, the contractor's crew began paving Section 2 with Type 1 base course containing AR. Two 3-in. lifts were constructed. Asphalt content of the mix was 4.3 percent. The AR contained 10-percent RTR, resulting in 0.43-percent rubber in the hot mix. Soap was added to the water in the roller to eliminate any potential problems of picking up the mix. No problems were experienced with laydown and compaction except for the odor noted by the paving crew. This base course was overlaid with a 1.5-in. lift of Type 3 AR binder course and a 1.5-in. lift of Type 6F AR top course. AR was also used for a 1.5-in. lift of Type 6F top course over the conventional Type 1 base and Type 3 binder courses of Section 1. No problems were reported during paving.

2. Rubber-Modified Hot-Mix Asphalt (RUMAC)

Test Sections 3 and 4 were constructed with 2-percent RUMAC Type 1 base course. Each section contained two 3-in. lifts of RUMAC base course. The mix came from the truck and went through the paver without any problems, but some were noted during its compaction. The mix was tender and checked under the roller. To prevent pushing and shoving of the mat, the roller operator broke down the mat with two vibratory passes up to the paver and then waited until it cooled to about 160 deg F to finish rolling. The higher temperature needed to produce and place the mix increased the time for the mat to cool sufficiently before finish rolling.

A few days after paving the second lift of RUMAC base course, it was discovered that an area of the RUMAC base in Test Section 3 had failed. About 90 ft of the northbound lane had stripped and ravelled. The ravelled area was still wet from overnight rain, suggesting that moisture had penetrated and remained in the pavement. Material from the failed sections was removed and replaced with new 2-percent RUMAC base mix.

Sections 3 and 4 were then paved with a 1.5-in. lift of 2-percent RUMAC Type 3 binder. The roller pattern used on the RUMAC base was also used to compact the RUMAC binder. The Region 1 Materials Engineer changed the mix design for the northbound lane of the binder mix, making it coarser with less sand to increase the air voids. This was an attempt to find a modified mix design that could be compacted with a conventional rolling pattern. The revised 2- percent RUMAC Type 3 binder mix did not react any differently during compaction than the original 2-percent RUMAC mix, and was compacted using the modified roller pattern.

A few weeks later potholes and ravelling were reported in an area of the original 2-percent RUMAC binder mixture in Test Section 4, involving about 200 ft in the southbound lane at the extreme north end of the project. Region 1 Materials and Construction personnel met with Main Office Materials Bureau representatives to discuss repair, and it was agreed to remove the ravelled 2-percent material and replace it with 1-percent RUMAC Type 3 binder. The 1-percent RUMAC Type 6F top course was eliminated from the project to supply rubber for the 1-percent replacement binder mix.

Work on the 2-percent ravelled binder was started using a front-end loader and grader. This material was extracted easily but pavement outside the ravelled area could not be removed using this equipment. Work stopped until a milling machine could be located. During the initial removal, the ravelled material was found to be only 1-in. thick. Given the top-size aggregate for this mix, it is unlikely that sufficient density was achieved in this area. The surrounding unravelled mix was 1.25 to 1.5 in. thick. The milling machine arrived and the remaining 1800 ft was removed. Due to logistical problems, the millings were used as fill elsewhere and not recycled. The milled surface received a tack coat before placing the 1-percent RUMAC binder. The same roller pattern was needed on the 1-percent as on the 2-percent RUMAC mix. A conventional 6F top course was paved over both RUMAC binders. As constructed, the test sections were as also listed in Table 1.

Some health-related problems were reported when the 2-percent RUMAC was paved. After five continuous days of CRM HMA paving, the paver operator and a laborer became ill, one with bronchitis-like symptoms and the other with a severe nosebleed. Due to these problems and complaints from plant personnel and paving inspectors about odor, air quality was monitored for hydrocarbons during August. Monitors were worn by the paver operator and another crew member to collect air samples during actual paving. Results of this testing are given in Appendix B.

Falling-weight deflectometer (FWD) testing was performed after paving was completed, providing data on structural strength of pavement sections, with the results included in Appendix C. Cores were also taken in each test section to determine air voids for each mix type. Results are given in Appendix B.

Hot-mix samples from each mix were taken during paving and will be tested for Marshall properties and resilient modulus.

III. OBSERVATIONS, CONCLUSIONS, AND RECOMMENDATIONS

A. Observations and Conclusions

When producing RUMAC or AR mixes, mix temperature must be increased about 25 deg F to increase workability. When using AR, it should be noted that it is more viscous than standard AC-20. Some plants may have problems pumping the AR with existing equipment.

No major problems were reported concerning construction of any of the test sections, but some modifications of the rolling pattern were required to compact the RUMAC courses properly. When hot, mats of these courses were spongy and checked under the roller. It was found that the roller had to break down the mat immediately after paving and then wait until it cooled to about 160 F before finish rolling -- at that cooler temperature, the mat moved less under the roller. To prevent shoving, RUMAC mixes must cool more than AR or conventional mixes before opening to traffic.

Results of air quality testing indicated that RUMAC air samples and conventional asphalt-concrete-paving air samples were essentially the same. Worker exposure to hydrocarbons was below permissible exposure limits (PELs). Nitrates, sulfides, aldehydes, and phenyls were monitored but not detected. Air sampling results suggest that a respirator is not needed to prevent overexposure to inhalation of fumes when producing RUMAC or AR mixes. Experience from this project indicates that rubber mixes caused irritation to some of the workers.

The finished pavement was cored and tested for percent air voids. Cores containing 2-percent RUMAC had higher in-place air voids than those containing conventional HMA or 1-percent RUMAC. This indicates that compaction procedures or mix gradations may have to be altered to achieve higher densities for 2-percent RUMAC mixes. Air voids also vary more among samples containing higher percentages of rubber than those having less or no rubber. Visual inspection of the cores showed good distribution of rubber in the RUMAC mixes.

The finished pavement was tested with the falling-weight deflectometer. Larger deflections were found for the AR test sections containing crumb-rubber modifier by the wet process. The 2% RUMAC test section had the second highest deflections followed by the 1% RUMAC test section with the conventional control section having the least amount of deflection. This suggests that crumb rubber increases the flexibility of the pavement, and in the future may prove to provide better fatigue properties. However, the greater the deflection in the asphalt pavement the greater the deflection in the subgrade. The effect on the pavement's performance due to the increased deflection of the subgrade is unknown at the present time.

In general, the cost of paving RUMAC and AR mixes was double that of conventional HMA. Conventional hot mix ranged from \$22 - \$27 per ton while RUMAC mixes ranged from \$55 - \$65 per ton and AR mixes ranged from \$40 - \$50 per ton. Higher cost may be partially due to the change order, but most of the increase can be attributed to CRM and AR expense, extra labor involved at the plant and during placement, and reduced production rates. It is anticipated that costs may

decrease as methods of adding rubber are improved and larger projects are built. A cost analysis for this project is given in Appendix E.

C. Recommendations

In the future, the Department should look more closely at mix designs for RUMAC mixes. Effects of variations in aggregate and CRM gradation should be investigated. CRM absorbs some of the AC; a finer CRM gradation would have increased surface area, speed up the reaction taking place with the AC, and increase the amount of AC absorbed. Other methods of blending CRM with AC for production of AR should be evaluated. Some methods create a product having a short storage life. Sampling and testing procedures are needed for AR products. Compaction procedures for RUMAC mixes and the effectiveness of nuclear gages on RUMAC and AR mixes should also be studied.

Engineering properties of rubber-modified mixes should be investigated to determine possible benefits. It is not yet known if the added cost of CRM asphalt pavement will be offset by longer life. Long-term pavement inspections will be needed to determine if adding CRM will improve asphalt pavement performance and extend its life. Pavement inspections will also be necessary to determine if the higher percent air voids typical of the crumb-rubber modified sections will have an effect on pavement performance.

Further research is also needed to determine if problems occur when RUMAC or AR pavement is recycled. Recycling asphalt pavement containing RTR has not been attempted in New York and very little recycling has been reported nationwide.

Finally, evaluation and reporting of pavement performance, structural properties, and durability should continue. Performance of these Route 32 sections should be compared to that of the adjacent conventional control section.

APPENDIX A

MIX DESIGNS

BR 344b (2/89)

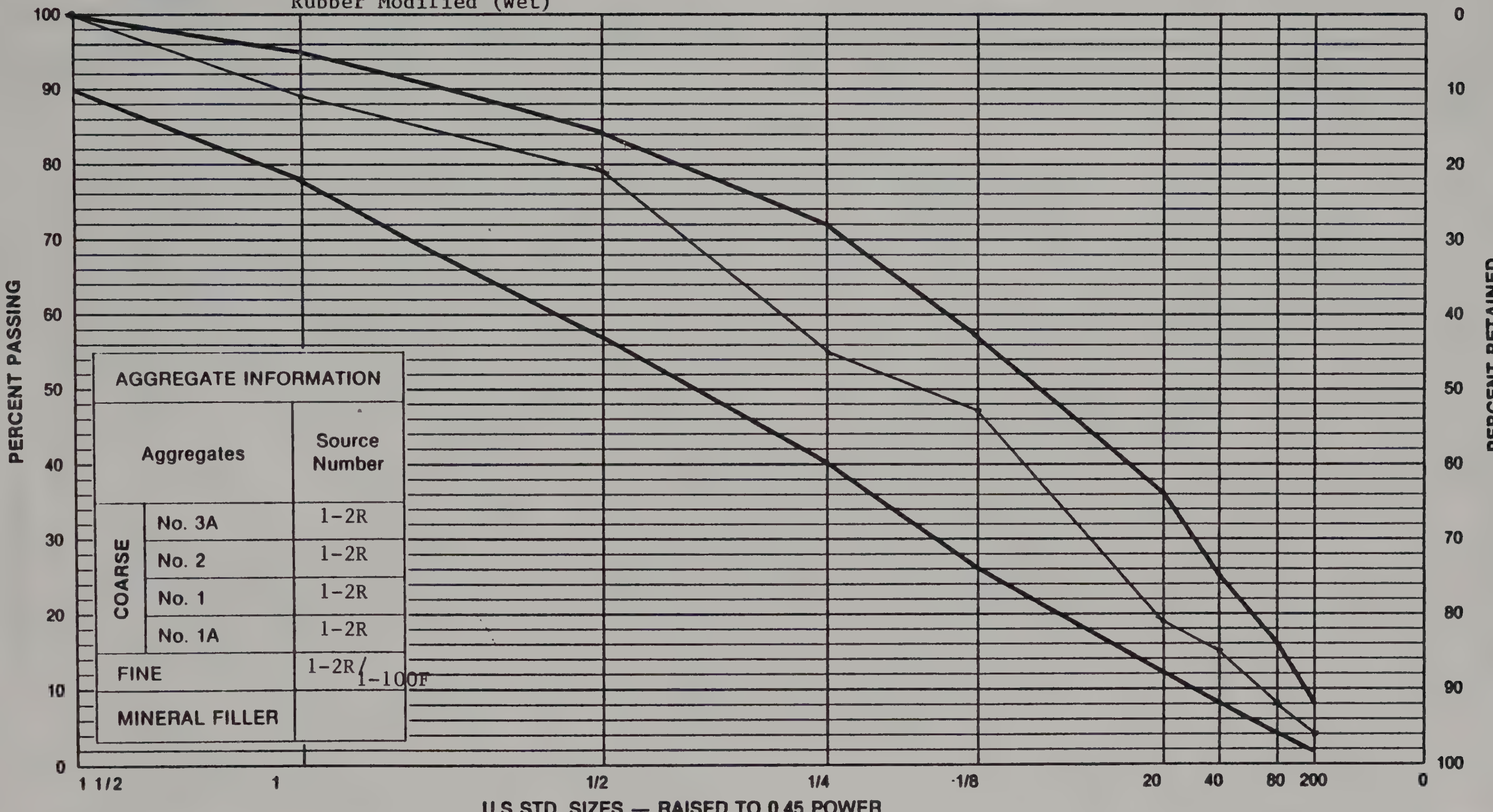
NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

JOB MIX FORMULA

Type 1 Base (Dense)
Rubber Modified (Wet)

Facility No.________ Formula No.________
Plant________ Region 1
Plant Location________
Submitted By________ Date 7/1/93

(SUBMISSION INSTRUCTIONS ON BACK)



AGGREGATE INFORMATION		
Aggregates		Source Number
COARSE	No. 3A	1-2R
	No. 2	1-2R
	No. 1	1-2R
	No. 1A	1-2R
FINE		1-2R/1-100F
MINERAL FILLER		

Sieve Size		2"	1 1/2"	1"	1/2"	1/4"	1/8"	No. 20	No. 40	No. 80	No. 200	Asphalt Content (Percent)
% Passing	1. General Limits	100	90-100	78-95	57-84	40-72	26-57	12-36	8-25	4-16	2-8	4.0-6.0
	2. JMF Range	100	90-100	84-94	73-84	48-62	40-54	12-26	8-22	4-12	2-6	4.0-4.7
	3. Target Value	100	100	89	79	55	47	19	15	8	4	4.3

Asphalt Grade
AC **

Approved by Regional Director________ Date________

Remarks: **Bitumar Inc. Paving Asphalt - Asphalt Rubber

BR 344b (2/89)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

JOB MIX FORMULA

Type 1 Base (Dense)
Rubber Modified (Dry)

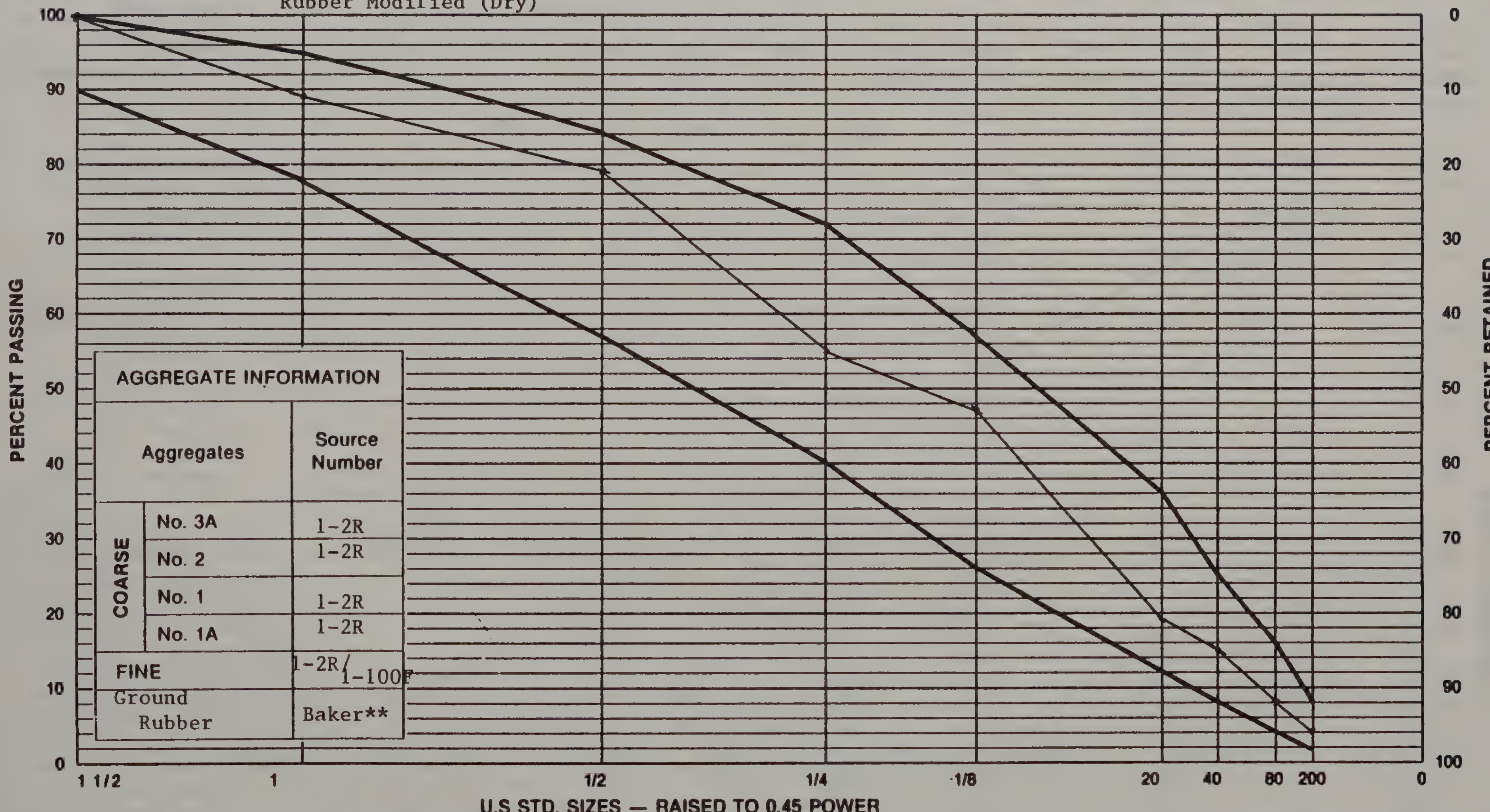
Facility No.______ Formula No.______

Plant______ Region 1

Plant Location______

Submitted By______ Date 7/1/93

(SUBMISSION INSTRUCTIONS ON BACK)



AGGREGATE INFORMATION		
	Aggregates	Source Number
COARSE	No. 3A	1-2R
	No. 2	1-2R
	No. 1	1-2R
	No. 1A	1-2R
FINE		1-2R/1-100F
Ground Rubber		Baker**

Sieve Size		2"	1 1/2"	1"	1/2"	1/4"	1/8"	No. 20	No. 40	No. 80	No. 200	Asphalt Content (Percent)
% Passing	1. General Limits	100	90-100	78-95	57-84	40-72	26-57	12-36	8-25	4-16	2-8	4.0-6.0
	2. JMF Range	100	90-100	84-94	73-84	48-62	40-54	12-26	8-22	4-12	2-6	4.3-5.1
	3. Target Value	100	100	89	79	55	47	19	15	8	4	4.7

Asphalt Grade
AC 20

Approved by Regional Director______ Date______

Remarks: ** 2% ground rubber Baker Rubber Inc. (Baker Code: WRF-10/30)

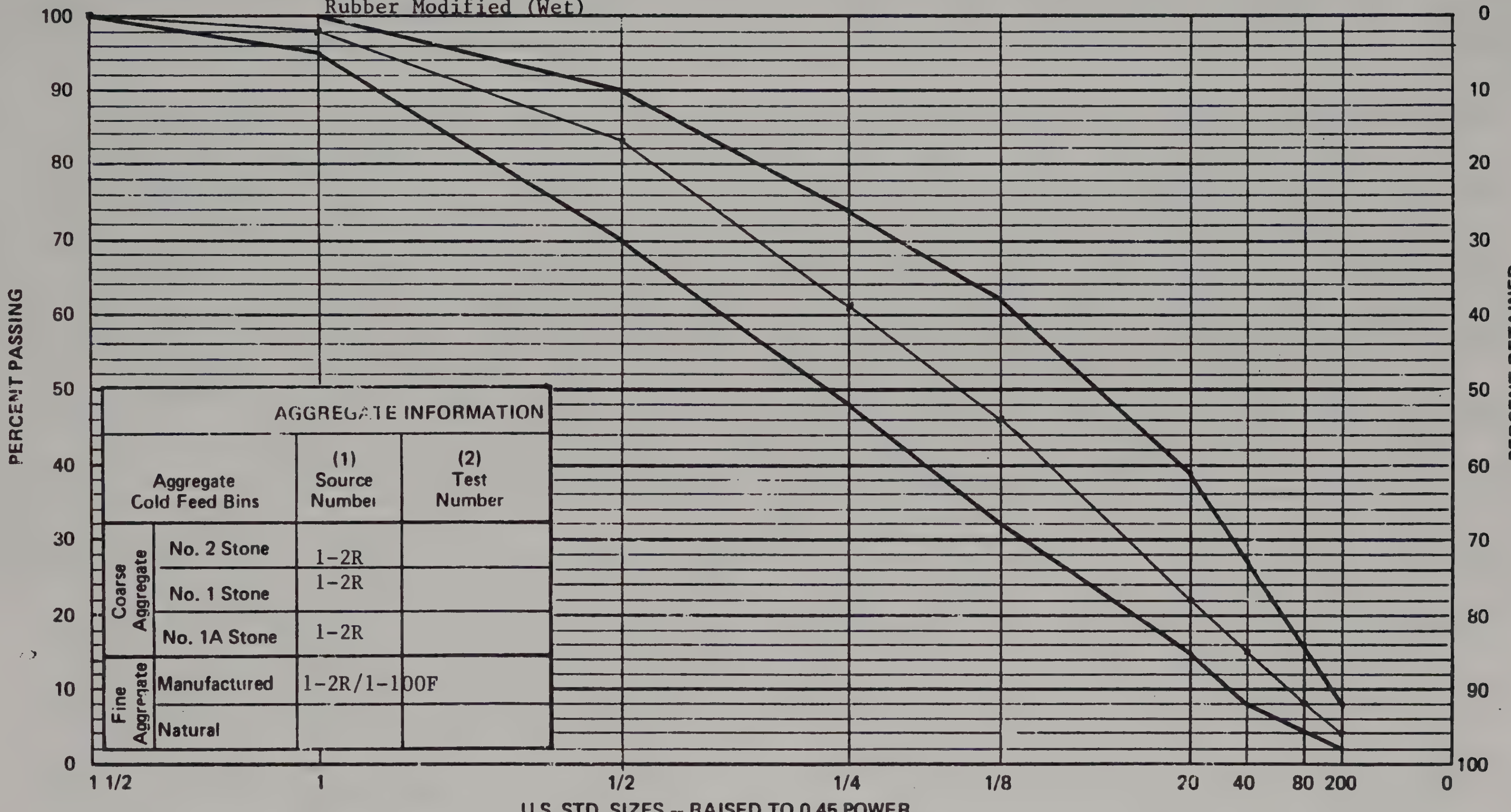
BR 298-1 (2/78)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

JOB MIX FORMULA

Type 3, Binder (Dense)
Rubber Modified (Wet)

Region 1 Formula No. ______
Plant ______ Pugmills ______
Plant Location ______
Submitted By ______ Title ______
(Submission instructions on back) 7/1/93



AGGREGATE INFORMATION

Aggregate Cold Feed Bins		(1) Source Number	(2) Test Number
Coarse Aggregate	No. 2 Stone	1-2R	
	No. 1 Stone	1-2R	
	No. 1A Stone	1-2R	
Fine Aggregate	Manufactured	1-2R/1-100F	
	Natural		

Sieve Size		2"	1 1/2"	1"	1/2"	1/4"	1/8"	No. 20	No. 40	No. 80	No. 200	Asphalt Content (Percent)
% Passing	1. General Limits		100	95-100	70-90	48-74	32-62	15-39	8-27	4-16	2-8	4.5-6.5
	2. JMF Range		100	95-100	77-89	54-68	39-53	15-29	8-22	4-12	2-6	4.5-5.0
	3. Target Value		100	98	83	61	46	22	15	8	4	4.6

Asphalt Grade
AC**

Remarks ** Bitumar Inc. Paving Asphalt - Asphalt Rubber

Approved ______ Date ______
Regional Director

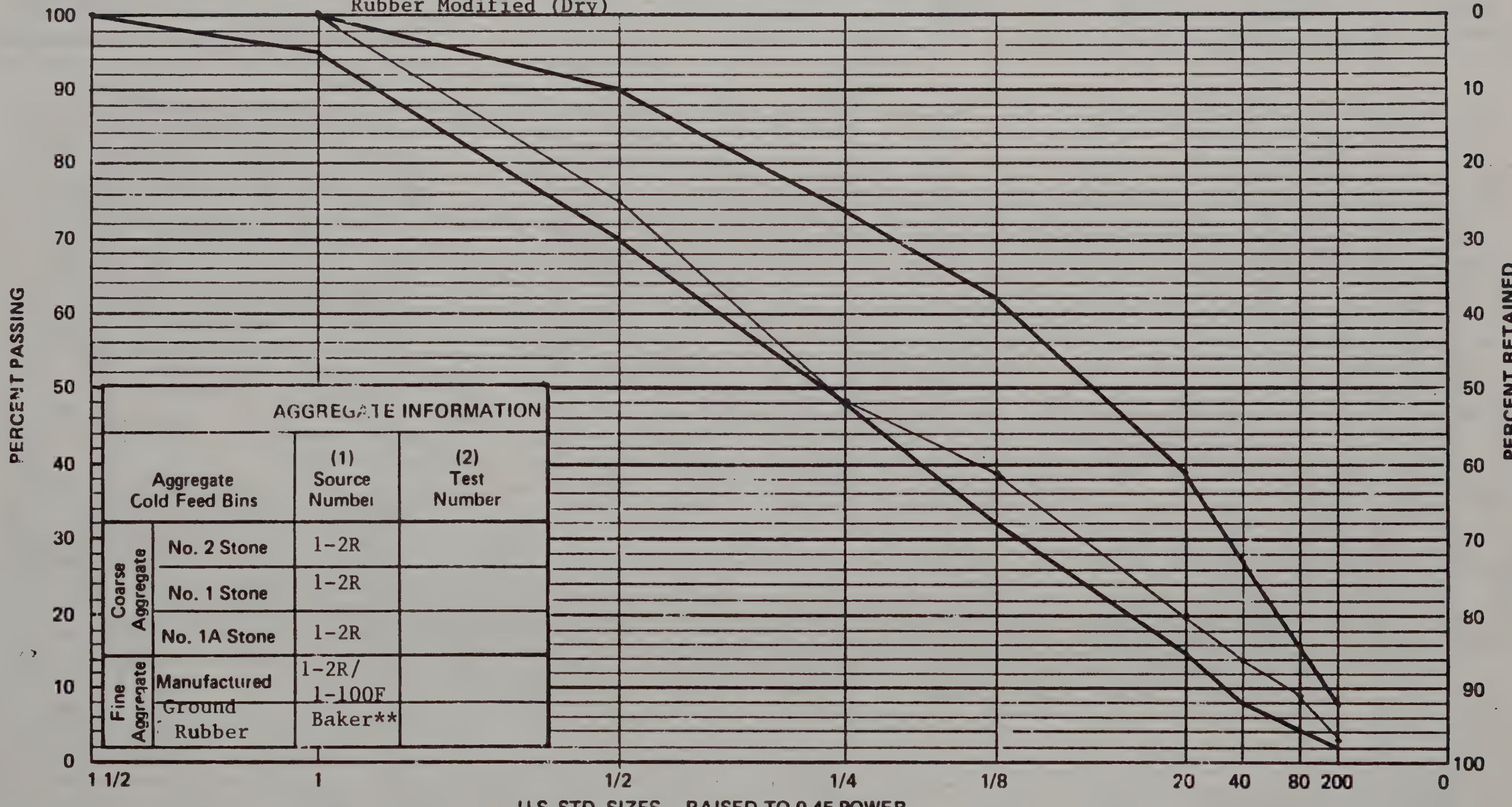
BR 298-1 (2/78)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

JOB MIX FORMULA

Type 3, Binder (Dense)
Rubber Modified (Dry)

Region 1 Formula No. ______
Plant ______ Pugmills ______
Plant Location ______
Submitted By ______ Title ______
(Submission instructions on back) 9/25/93



AGGREGATE INFORMATION

	Aggregate Cold Feed Bins	(1) Source Number	(2) Test Number
Coarse Aggregate	No. 2 Stone	1-2R	
	No. 1 Stone	1-2R	
	No. 1A Stone	1-2R	
Fine Aggregate	Manufactured	1-2R/ 1-100F	
	Ground Rubber	Baker**	

Sieve Size		2"	1 1/2"	1"	1/2"	1/4"	1/8"	No. 20	No. 40	No. 80	No. 200	Asphalt Content (Percent)
% Passing	1. General Limits		100	95-100	70-90	48-74	32-62	15-39	8-27	4-16	2-8	4.5-6.5
	2. JMF Range		100	95-100	69-82	42-55	32-46	13-27	7-21	5-13	2-5	4.5-5.2
	3. Target Value		100	100	75	48	39	20	14	9	3	4.8

Asphalt Grade
AC 20

Remarks ** 1% ground rubber (Baker Code: WRF - 10/30)

COARSER REVISED MIX

Approved ______ Date 9/27/93
Regional Director

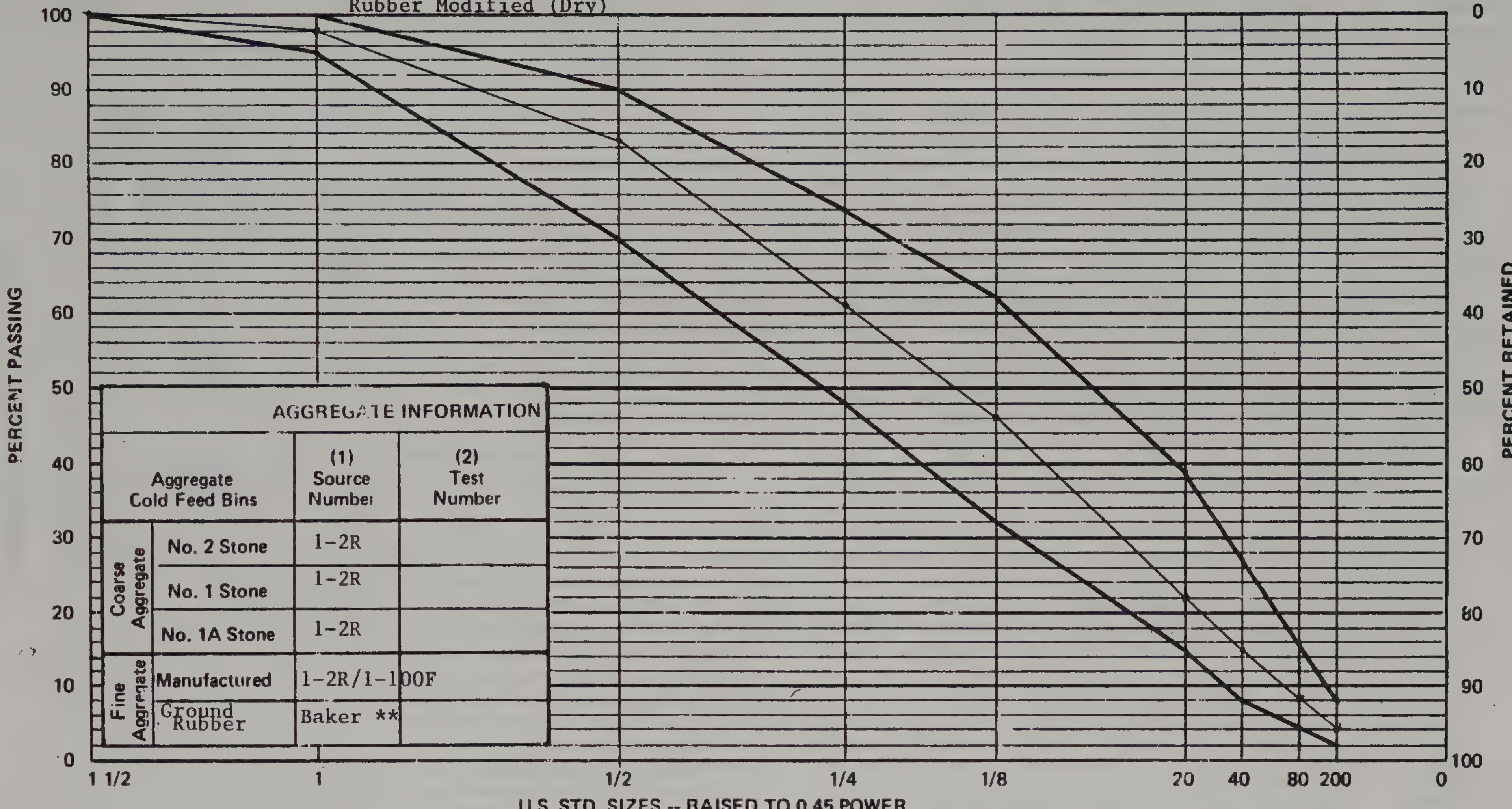
BR 298-1 (2/78)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

JOB MIX FORMULA

Type 3, Binder (Dense)
Rubber Modified (Dry)

Region 1 Formula No. ______
Plant ______ Pugmills ______
Plant Location ______
Submitted By ______ Title ______
(Submission instructions on back) 9/25/93



AGGREGATE INFORMATION

	Aggregate Cold Feed Bins	(1) Source Number	(2) Test Number
Coarse Aggregate	No. 2 Stone	1-2R	
	No. 1 Stone	1-2R	
	No. 1A Stone	1-2R	
Fine Aggregate	Manufactured	1-2R/1-100F	
	Ground Rubber	Baker **	

Sieve Size		2"	1 1/2"	1"	1/2"	1/4"	1/8"	No. 20	No. 40	No. 80	No. 200	Asphalt Content (Percent)
% Passing	1. General Limits		100	95-100	70-90	48-74	32-62	15-39	8-27	4-16	2-8	4.5-6.5
	2. JMF Range		100	95-100	77-89	54-68	39-53	15-29	8-22	4-12	2-6	4.5 - 5.2
	3. Target Value		100	98	83	61	46	22	15	8	4	4.8

Asphalt Grade
AC 20

Remarks ** 1% ground rubber (Baker Code: WRF - 10/30)

ORIGINAL MIX

Approved ______ Date 9/27/93
Regional Director

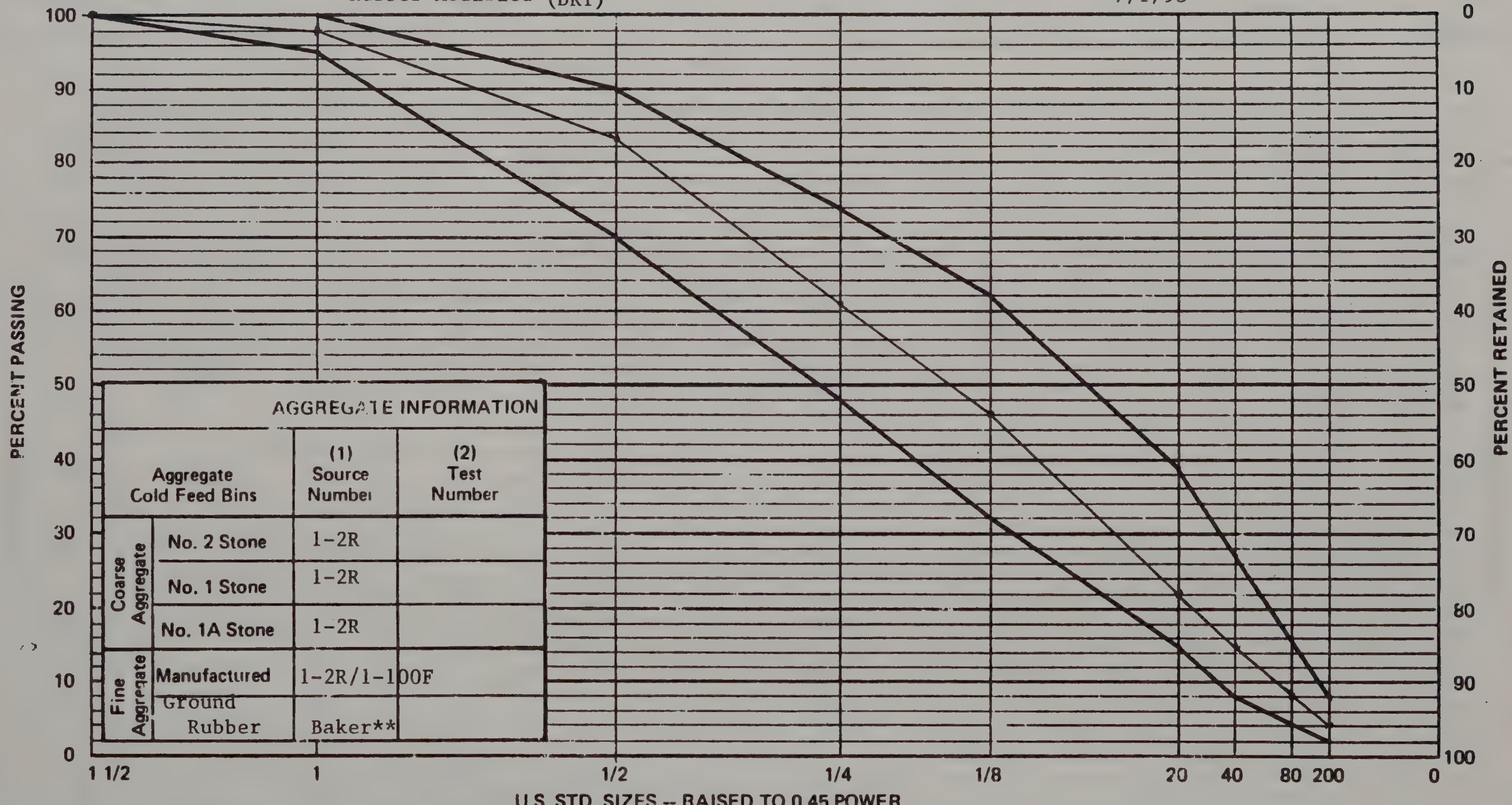
BR 298-1 (2/78)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

JOB MIX FORMULA

Type 3 Binder (Dense)
Rubber Modified (DRY)

Region 1 Formula No. ______
Plant ______ Pugmills ______
Plant Location ______
Submitted By ______ Title ______
(Submission instructions on back) 7/1/93



AGGREGATE INFORMATION

	Aggregate Cold Feed Bins	(1) Source Number	(2) Test Number
Coarse Aggregate	No. 2 Stone	1–2R	
	No. 1 Stone	1–2R	
	No. 1A Stone	1–2R	
Fine Aggregate	Manufactured	1–2R/1–100F	
	Ground Rubber	Baker**	

Sieve Size		2"	1 1/2"	1"	1/2"	1/4"	1/8"	No. 20	No. 40	No. 80	No. 200	Asphalt Content (Percent)
% Passing	1. General Limits		100	95-100	70-90	48-74	32-62	15-39	8-27	4-16	2-8	4.5-6.5
	2. JMF Range		100	95–100	77–89	54–68	39–53	15–29	8–22	4–12	2–6	4.6–5.4
	3. Target Value		100	98	83	61	46	22	15	8	4	5.0

Asphalt Grade
AC 20

Remarks ** 2% ground rubber (Baker Code: WRF-10/30)

Approved ______ Date ______
Regional Director

BR 172a (2/89)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

JOB MIX FORMULA

Rubber Modified (WET)

Type 6F Top Course (High Friction)

Facility No. ______ Formula No. ______

Plant ______ Region 1

Plant Location ______

Submitted By ______ Date 8/6/93

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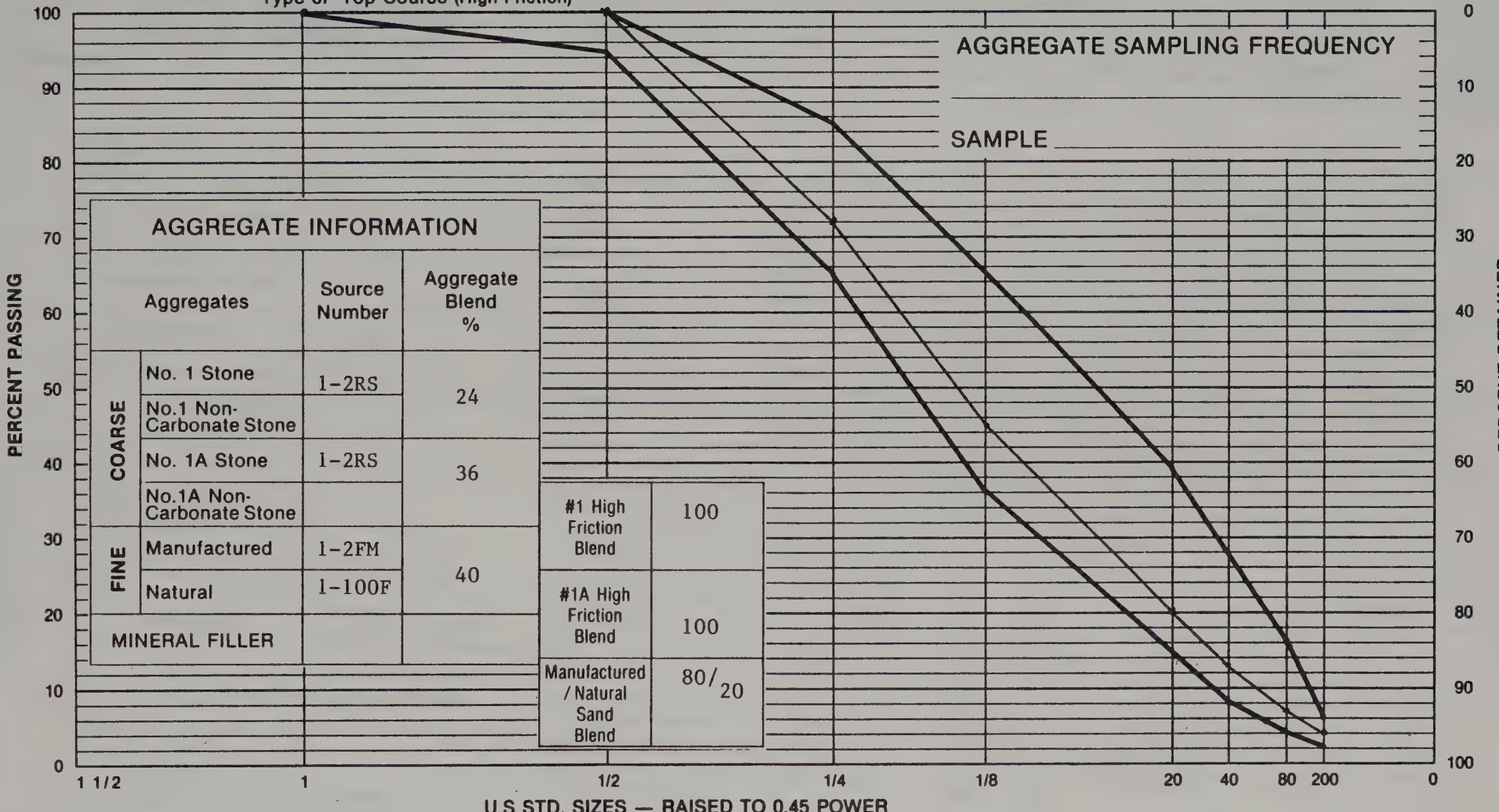


AGGREGATE SAMPLING FREQUENCY ______

SAMPLE ______

AGGREGATE INFORMATION

	Aggregates	Source Number	Aggregate Blend %
COARSE	No. 1 Stone	1-2RS	24
	No.1 Non-Carbonate Stone		
	No. 1A Stone	1-2RS	36
	No.1A Non-Carbonate Stone		
FINE	Manufactured	1-2FM	40
	Natural	1-100F	
MINERAL FILLER			

#1 High Friction Blend	100
#1A High Friction Blend	100
Manufactured / Natural Sand Blend	80/20

Sieve Size		2"	1 1/2"	1"	1/2"	1/4"	1/8"	No. 20	No. 40	No. 80	No. 200	Asphalt Content (Percent)
% Passing	1. General Limits			100	95-100	65-85	36-65	15-39	8-27	4-16	2-6	5.8-7.0
	2. JMF Range			100	95-100	65-79	38-52	15-27	8-20	4-11	2-6	5.6
	3. Target Value			100	100	72	45	20	13	7	4	

Asphalt Grade
AC **

Recommended for Approval by Regional Director ______ Date 8/20/93

Approved by Director, Materials Bureau ______ Date ______

Remarks: ** Bitumar Inc. Paving Asphalt - Asphalt Rubber

BR 172a (2/89)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

JOB MIX FORMULA

Rubber Modified (DRY)

Type 6F Top Course (High Friction)

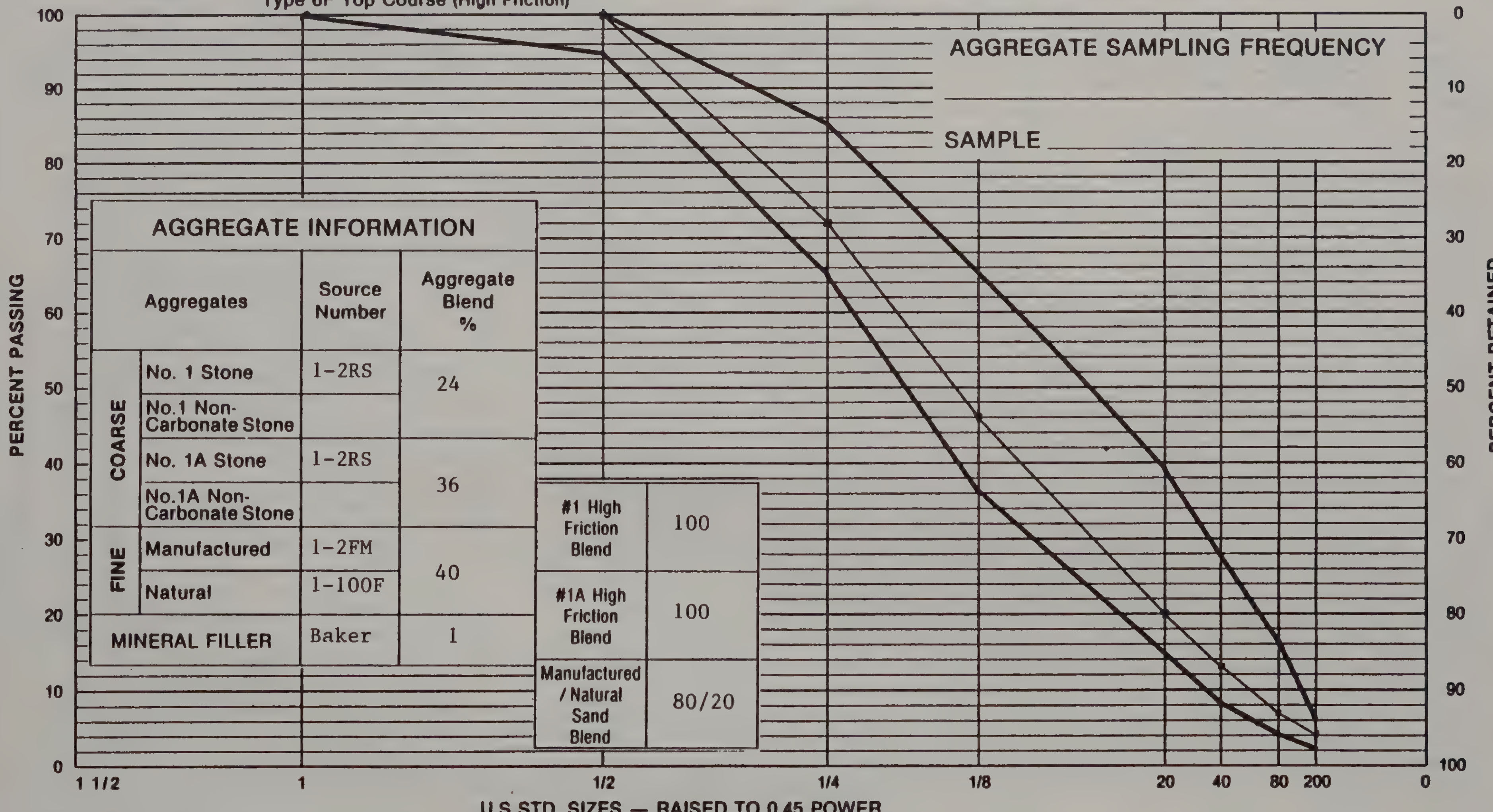
Facility No. ______ Formula No. ______

Plant ______ Region I

Plant Location ______

Submitted By ______ Date 7/30/93

(SUBMISSION INSTRUCTIONS ON BACK)



AGGREGATE INFORMATION

	Aggregates	Source Number	Aggregate Blend %
COARSE	No. 1 Stone	1-2RS	24
	No.1 Non-Carbonate Stone		
	No. 1A Stone	1-2RS	36
	No.1A Non-Carbonate Stone		
FINE	Manufactured	1-2FM	40
	Natural	1-100F	
MINERAL FILLER		Baker	1

#1 High Friction Blend	100
#1A High Friction Blend	100
Manufactured / Natural Sand Blend	80/20

Sieve Size		2"	1 1/2"	1"	1/2"	1/4"	1/8"	No. 20	No. 40	No. 80	No. 200	Asphalt Content (Percent)
% Passing	1. General Limits			100	95-100	65-85	36-65	15-39	8-27	4-16	2-6	5.8-7.0
	2. JMF Range			100	95-100	65-79	39-53	15-27	8-20	4-11	2-6	6.0
	3. Target Value			100	100	72	46	20	13	7	4	

Asphalt Grade
AC 20

Recommended for Approval by Regional Director ______ Date ______

Approved by Director, Materials Bureau ______ Date ______

Remarks: Baker Ground Rubber Code: WRF-10/30 . 1% Ground rubber

BAKER RUBBER INC.

CRUMB RUBBER GRADATION

Baker Code: WRF-10/30

Sieve Size	Percent Passing
1/8"	100
No. 10	95+/-5
No. 20	30+/-5
No. 40	10+/-5

APPENDIX B

AIR QUALITY TEST RESULTS

MEMORANDUM
DEPARTMENT OF TRANSPORTATION

TO: W. Brule, Materials Bureau, 7A-210

FROM: Barry Ross, Employee Safety & Health, 5-102 B Ross

SUBJECT: ASPHALT FUMES DURING INSTALLATION OF RUBBER MODIFIED ASPHALT CONCRETE

DATE: November 5, 1993

INTRODUCTION - Employees of Callanan Industries alleged medical symptoms due to installing rubber modified asphalt concrete (RMAC) on contract D253962, Route 32 reconstruction, Albany County. Three employees complained of symptoms that included nose bleeds, respiratory irritation and bronchitis. The RMAC that was installed on the days in question (7/22, 7/25 & 7/26) was a product compounded with 2% dry rubber.

METHODOLOGY - Air samples were collected during the installation of RMAC containing crumb rubber and during the installation of standard asphalt concrete. Both materials were prepared at the Callanan plant in South Bethlehem, Albany County. On August 12, 1993, air samples were collected for Polynuclear Aromatics (PNA), and total volitile organics during installation of RMAC. Liberty Mutual was also at the work site, collecting samples for asphalt fume. On August 13, 1993, samples for PNA and total volatile organics were collected during the installation of standard asphalt concrete for comparison.

On October 4, 1993, the asphalt fume was tested for phenolics, oxides of sulfur and nitrogen, acetaldehyde, and petroleum solvents, using detector tubes manufactured by the National Draeger Company, during installation of RMAC.

RESULTS - The values for asphalt fume, polynuclear aromatics, and total volatile organics were virtually the same. Comparison of the chromotograms found no difference between the RMAC and standard asphalt concrete. (See attached table).

The tests for phenolics, oxides of sulfur and nitrogen, and acetaldehyde were negative. The petroleum solvent was approximately 25 PPM, well within the accepted range of airborne levels.

OBSERVATIONS - The exposure encountered by the paving crew members is greatly dependent on atmospheric conditions. Calm days will allow the asphalt fume to accumulate around the workers. The variability of exposure makes it difficult to accurately predict the effect of components of the RMAC on employees. The RMAC has a strong odor of hot rubber tires. This odor appears to be objectionable to most employees, though no health problems could be directly associated with it.

RECOMMENDATIONS - Use of respiratory protection for the paving machine operator, the employee riding on the screed, and the employee monitoring the dumping of material into the hopper is recommended. The use of respirators can be on an "as needed" basis, when the atmospheric conditions cause a build up of fumes around the paving machine and as a result employees find the fumes offensive. I would recommend that a fume filter cartridge be used with the respirators.

CONCLUSIONS - No component in the asphalt fume was found to be in the rubber modified asphalt concrete that caused the medical symptoms claimed by the paving crew.

BR:jmm

cc: D. W. Mencucci, Employee Safety & Health, 5-102
T. Melander, Construction, Region 1
P. Mack, Technical Services Div., 7A-210
P. Wells, Construction Division, 4-101
J. Bryden, Construction Division, 5-202C
G. Perregaux, Materials Bureau, 7A-220B

COMPARISON OF RMAC AND STANDARD ASPHALT CONCRETE

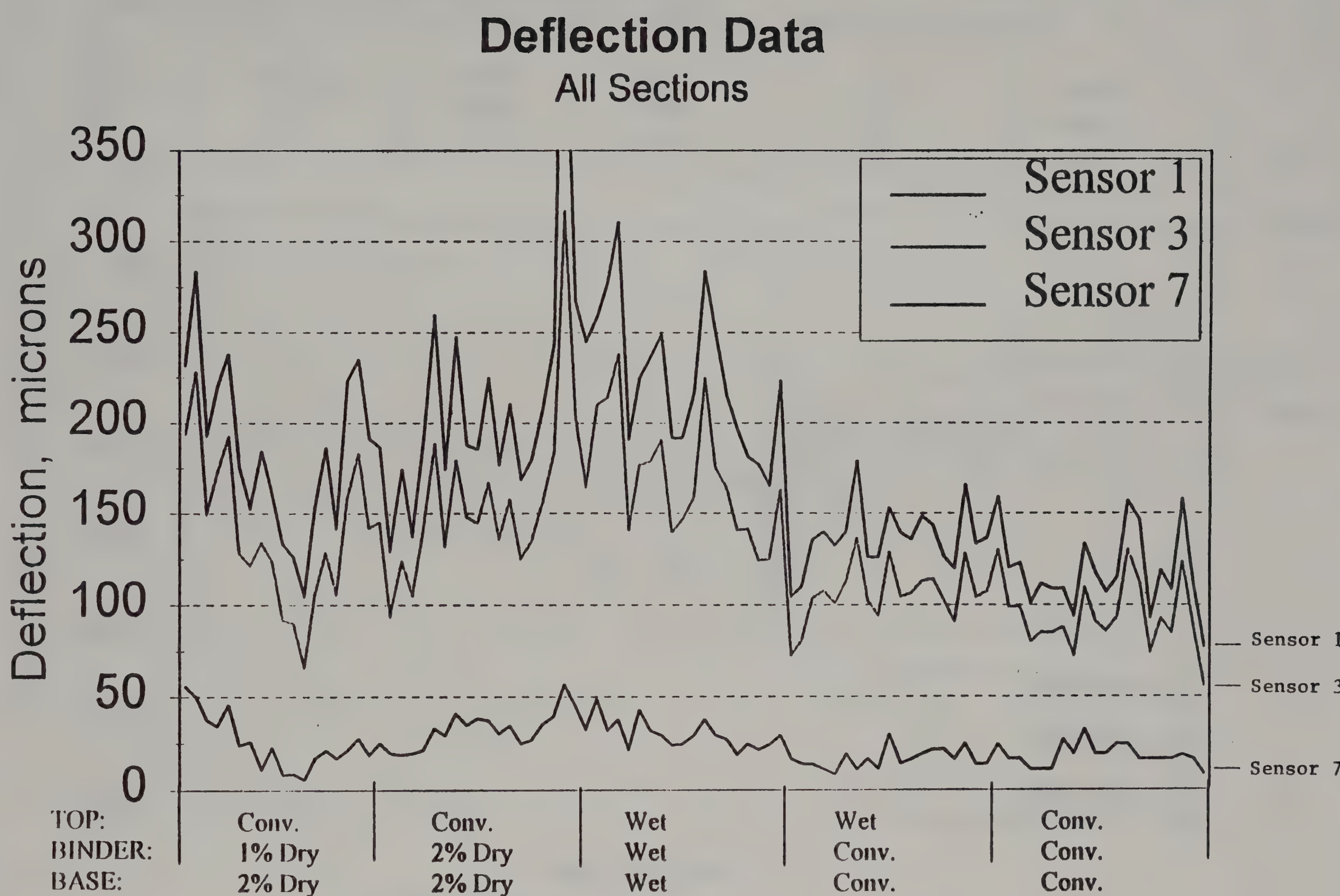
	RMAC	STANDARD AC	PERMISSABLE EXPOSURE LIMIT
Total Polynuclear Aromatis	.01 mg/m3	.004 mg/M	N/A
Total Organic Volatiles *	0.1 mg/M3	2.0 mg/M3	300 PPM
Asphalt Fume **	.74 mg/M3		5.0 mg/M3
	.61 mg/M3		5.0 mg/M3
	.41 mg/M3		5.0 mg/M3
Phenolics	Neg.		5 PPM
Acetaldehyde	Neg.		100 PPM
Sulfur dioxide	Neg.		5 PPM
Oxides of Nitrogen	Neg.		5 PPM
Petroleum distillates	25 PPM		500 PPM

* Comparison of chromatograms found no difference in composition

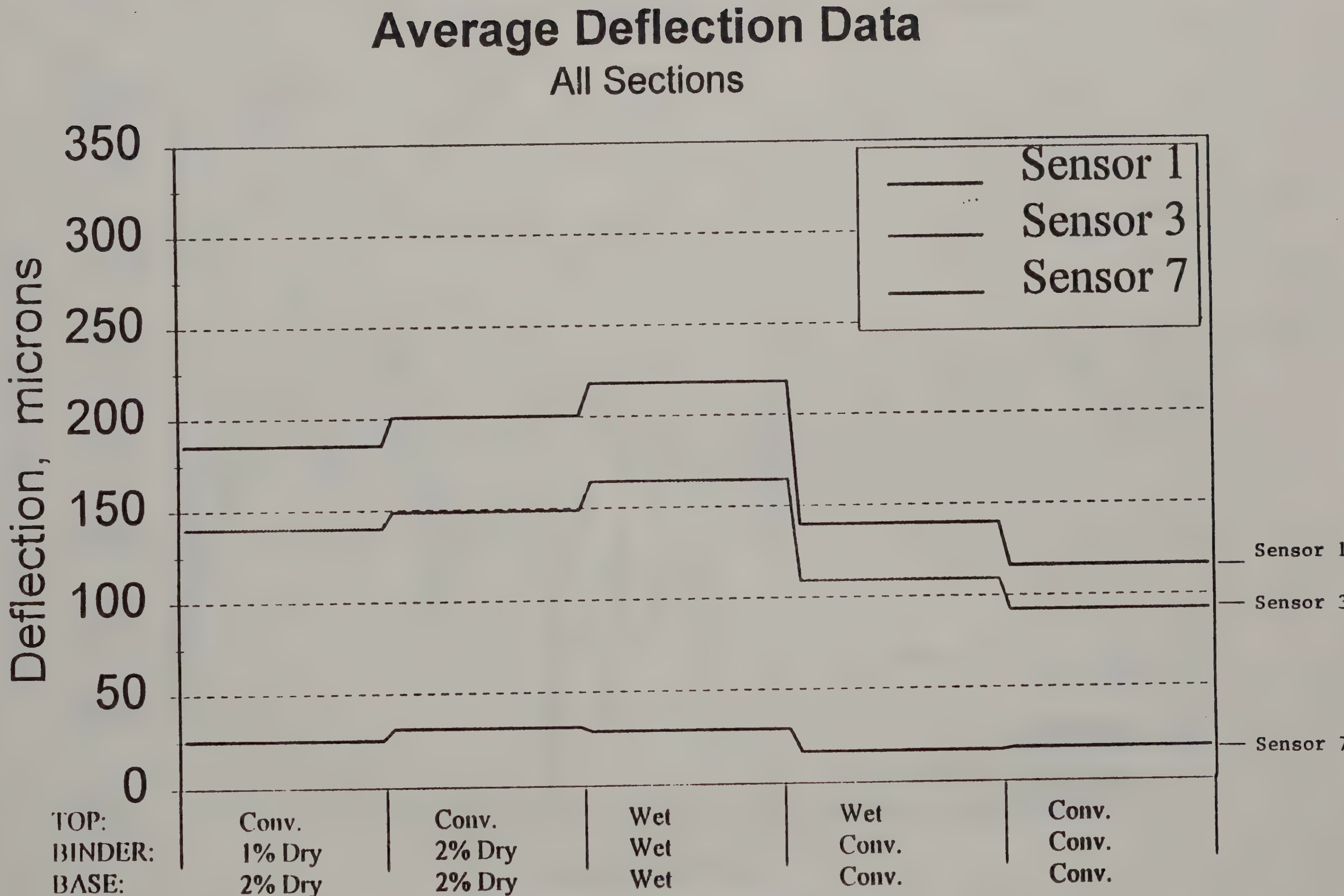
** Test performed by Liberty Mutual Insurance.

APPENDIX C

FALLING WEIGHT DEFLECTOMETER TEST RESULTS



Sensor 1 represents combined 3 layers - the pavement, the subbase, and the subgrade.
Sensor 3 represents the subbase and subgrade combined.
Sensor 7 represents the subgrade alone.



Sensor 1 represents combined 3 layers - the pavement, the subbase, and the subgrade.
Sensor 3 represents the subbase and subgrade combined.
Sensor 7 represents the subgrade alone.

APPENDIX D

PERCENT AIR VOIDS

APPENDIX D

RT. 32 FINISHED PAVEMENT CORES
LAB TEST RESULTS

CONVENTIONAL 6F TOP COURSE

Core No.	Density Bulk PCF	Bulk Spec. Grav.	Percent Air Voids
1A	142.8	2.288	6.84
2A	142.1	2.278	7.47
4B	142.8	2.288	7.56
5B	143.2	2.295	7.24
6B	142.6	2.285	7.64
10E	143.5	2.299	6.54
11E	145.1	2.326	5.56
12E	144.8	2.321	5.80
AVERAGE	143.4	2.298	6.83
STANDARD DEVIATION	1.00	0.02	0.75

AR 6F TOP COURSE

Core No.	Density Bulk PCF	Bulk Spec. Grav.	Percent Air Voids
7C	145.1	2.326	6.10
8C	143.4	2.298	7.11
9D	145.3	2.328	5.75
13D	140.3	2.248	8.69
14D	141.3	2.265	8.23
AVERAGE	143.1	2.293	7.18
STANDARD DEVIATION	2.0	0.0	1.1

1% RUMAC TYPE 3 BINDER COURSE

Core No.	Density Bulk PCF	Bulk Spec. Grav.	Percent Air Voids
1A	139.6	2.237	9.80
2A	142.1	2.277	7.74
3A	144.8	2.321	5.46
19A	142.9	2.290	7.32
20A	137.2	2.199	10.75
21A	144.5	2.315	6.54
AVERAGE	141.9	2.273	7.94
STANDARD DEVIATION	2.7	0.043	1.82

RT. 32 FINISHED PAVEMENT CORES
LAB TEST RESULTS (CONT.)

2% RUMAC TYPE 3 BINDER COURSE

4B	139.8	2.240	7.55
5B	137.7	2.206	9.11
6B	135.4	2.170	10.07
18B	133.0	2.131	12.63
17B	137.6	2.205	10.76
16B	130.7	2.095	14.14
AVERAGE	135.7	2.175	10.71
STANDARD DEVIATION	3.1	0.049	2.18

AR TYPE 3 BINDER COURSE

7C	143.7	2.303	8.10
8C	147.1	2.357	6.43
15C	146.3	2.344	6.84
AVERAGE	145.7	2.335	7.12
STANDARD DEVIATION	1.5	0.023	0.71

CONVENTIONAL TYPE 3 BINDER COURSE

10E	146.2	2.348	7.92
11E	145.6	2.334	7.01
12E	145.3	2.328	7.21
AVERAGE	145.7	2.337	7.38
STANDARD DEVIATION	0.4	0.008	0.39

AR TYPE 1 BASE COURSE

7C	150.0	2.404	4.94
8C	147.3	2.362	6.57
15C	149.4	2.395	4.73
AVERAGE	148.9	2.387	5.41
STANDARD DEVIATION	1.2	0.018	0.82

RT. 32 FINISHED PAVEMENT CORES
LAB TEST RESULTS (CONT.)

CONVENTIONAL TYPE 1 BASE COURSE

10E	143.5	2.299	8.95
11E	144.6	2.318	8.34
12E	148.3	2.376	6.31
AVERAGE	145.5	2.331	7.87
STANDARD DEVIATION	2.1	0.033	1.13

2% RUMAC TYPE 1 BASE COURSE

16B	137.6	2.205	12.01
17B	137.0	2.196	10.66
18B	138.4	2.218	8.95
AVERAGE	137.7	2.206	10.54
STANDARD DEVIATION	0.57	0.01	1.25

APPENDIX E

COST ANALYSIS

COST ANALYSIS

RUBBER USAGE 1993

ASPHALT RUBBER (AR):
(10% CRM AC)

Base:	0.43% rubber in mix; 1690 tons hot mix used
Binder:	0.46% rubber in mix; 625 tons hot mix used
Top:	0.56% rubber in mix; 1250 tons hot mix used

RUBBER-MODIFIED HOT-MIX ASPHALT (RUMAC):

Base:	2% rubber in mix; 3380 tons hot mix used
Binder:	2% rubber in mix; 625 tons hot mix used
Binder:	1% rubber in mix; 625 tons hot mix used

Tons of recycled rubber used:

(AR base) + (AR binder) + (AR top) + (RUM.base) + (RUMAC binder)
(0.0043*1690) + (0.0046*625) + (0.0056*1250) + (0.02*3380) + ((0.02*625)+(0.01*625))

= 103.492 tons of CRM

= 206,984 lb of rubber

assuming 12 lb of rubber per tire

= 17,249 tires

Additional cost of project was $250,000 which yields:

$14.49 per tire